National Aeronautics and
Space Administration

Educational Product	
Educators	Grades 5-8

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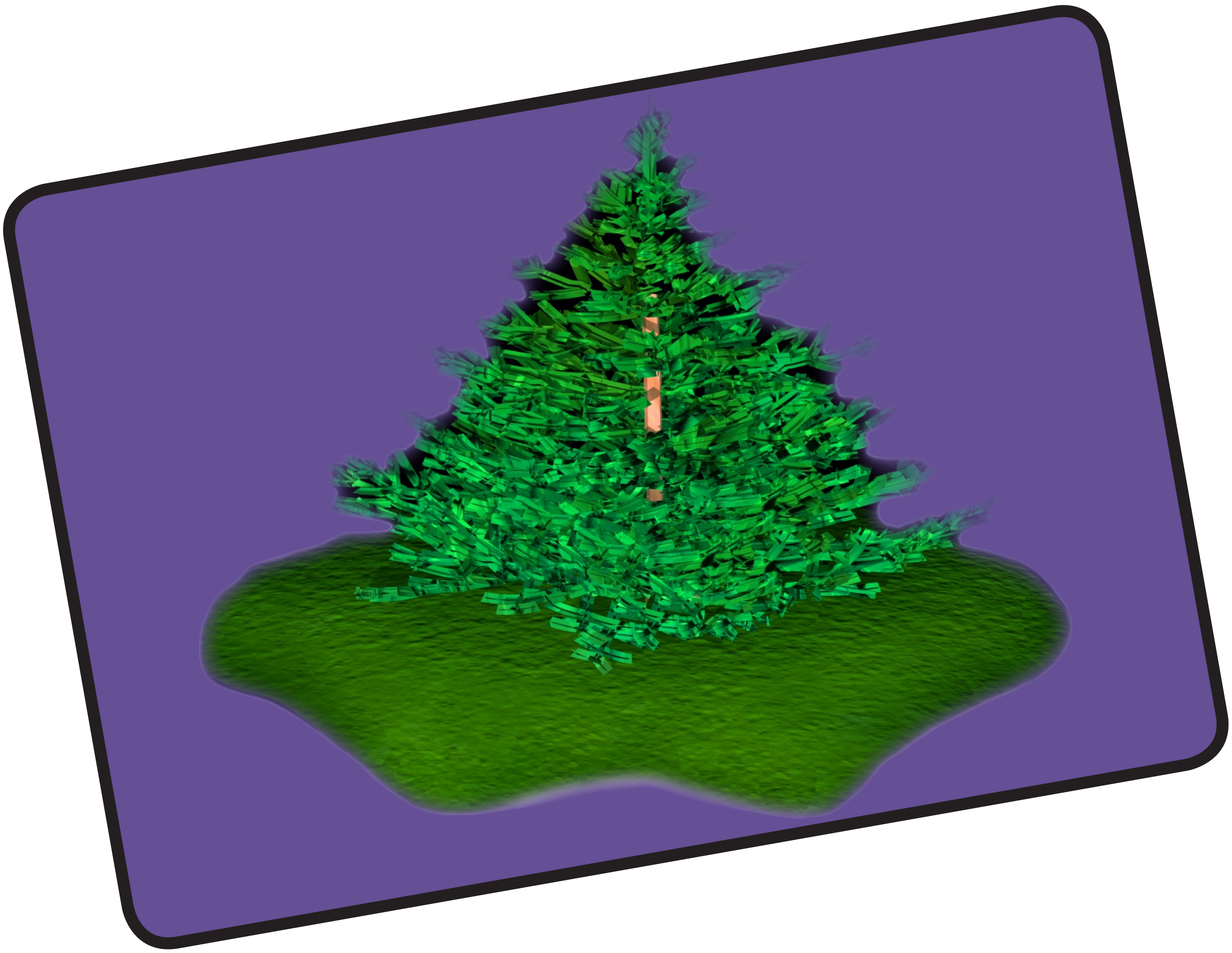
Astro-Venture: Biology Educator Guide

An Educator Guide with Activities in Biology and Astrobiology



http://astroventure.arc.nasa.gov

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Astro-Venture: Biology Educator Guide

National Aeronautics and Space Administration
Office of Education

Table of Contents

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Introduction

The Astro-Venture Biology Educator Guide has been developed by the National Aeronautics and Space Administration (NASA) for the purpose of increasing students' awareness of and interest in astrobiology and the many career opportunities that utilize science, math, and technology skills. The lessons are designed for educators to use with students in grades 5-8 in conjunction with the Astro-Venture multimedia modules on the Astro-Venture Web site http://astroventure.arc.nasa.gov.

The Astro-Venture Biology Educator Guide and online activities are designed to follow the Astro-Venture Astronomy, Atmospheric Science, and Geology Educator Guides and online modules. It is possible to take students through the Biology unit without having completed the other sections; however, it is assumed that educators will make sure that their students have mastered the prerequisite concepts prior to introducing these lessons. In particular, educators should consider implementing Astronomy Lesson 1: Unit Introduction and Astronomy Lesson 7: Thinking in Systems, as these two lessons introduce unifying concepts to which connections are made throughout Astro-Venture.

Astro-Venture Overview

Astro-Venture is an educational, interactive, multimedia Web environment highlighting NASA careers and astrobiology research in the areas of astronomy, geology, biology, and atmospheric sciences. Students in grades 5-8 role-play NASA occupations and use scientific inquiry as they search for and design a planet with the necessary characteristics for human habitation. Supporting activities include NASA Career Fact Sheets, trading cards and NASA Quest challenges (http://quest.nasa.gov) in which students engage in design problems or explorations supported by NASA scientists who provide answers to questions and feedback on solutions via Web chats and webcasts (live streaming audio and video).

Astro-Venture Overall Goal

Astro-Venture uses astrobiology content, the scientific inquiry process, and critical thinking skills to increase awareness of NASA careers and to educate students in grades 5-8 on the requirements of a habitable planet.

Astro-Venture Overall Objectives

1. Students in grades 5-8 will be able to identify and explain the vital characteristics of Earth that make it habitable to humans.

2. Students will use the process of scientific inquiry to explain the methods scientists use to find planets that have characteristics necessary to sustain human life.

3. Students will design a planet that has all of the necessary features to support human survival.

4. Students will identify at least one NASA occupation that best fits their interests and skills and will identify methods for pursuing a similar career.

Astro-Venture Structure

Astro-Venture is composed of online, interactive, multimedia modules and off-line classroom lessons. The story line and technology components provide the overall purpose and motivation for teaching the standards and concepts in the off-line lessons. The technology components also help to connect students to real science and scientists at NASA.

Astro-Venture is divided into five sections or "Research Areas."

1. Astronomy
2. Atmospheric Science
3. Geology
4. Biology
5. Design a Planet

The first four sections have the following components:

Training (The "Whats")
In each of these interactive, online, multimedia modules, students make changes to aspects of our solar system or to Earth and make observations of the effects on Earth. They then draw conclusions about the conditions that are required for human habitation in that science content area. In these training modules, students learn what humans need in a planet and star system to survive.

Classroom Lessons (The "Whys")
Offline, students engage in many classroom investigations in which they learn why humans need the requirements identified in the Training modules. These lessons have been developed to meet national education standards and build on each other to truly teach standards-based concepts such as: states of matter, systems, basic chemistry concepts, the structure of the Earth, and the flow of energy through food webs.

Missions (The "Hows")
After completing the training modules and lessons, students will engage in interactive, online, multimedia missions to simulate the methods scientists might use to search for a star system and planet that meet the qualifications identified in the training modules. In these modules, students learn how to go about finding a planet that would support human survival.

Design a Planet (Overall Assessment)
Once students have completed the first four sections, they will engage in the online, interactive, multimedia Design a Planet module in which they will design a simulated star system and planet that meets all human survival requirements in all four areas: astronomy, atmospheric sciences, geology, and biology.

Project 2061
In addition to meeting the National Science Education Standards, International Society for Technology in Education standards and National Council of Teachers on Mathematics standards, the Astro-Venture Biology Educator Guide is written to meet benchmarks found in the Benchmarks for Science Literacy produced by the American Association for the Advancement of Science (AAAS) as part of their science, math, and technology reform movement called Project 2061. The mission of Project 2061 is to "shape the future of education in America, a future in which all students [will] become literate in science, mathematics and technology by graduation from high school" (p. VII).1 "The Benchmarks for Science Literacy are statements of what all students should know or be able to do in science, mathematics and technology by the end of grades 2, 5, 8 and 12" (p. XI)2 and are based on extensive research of when and how it is developmentally appropriate to teach the concepts and skills described.

The table below shows how these benchmarks are identified for each lesson. There is a great deal of overlap between the Benchmarks for Science Literacy and the national science and math education standards. Therefore, we have also identified these standards, when appropriate. The first portion of the table entry identifies which standards or benchmarks are referenced. "2061" is a reference to the Benchmarks for Science Literacy. "NSES" is a reference to the National Science Education Standards. "NCTM" is a reference to the National Council of Teachers on Mathematics national mathematics education standards. "ISTE" is a reference to the International Society for Technology in Education standards. The second portion of the table entry identifies the specific standard referenced. In the case of Project 2061, the standard is referenced, the grade range and then the number of the concept under this standard and grade range. We distinguish between "meeting" benchmarks or standards, "partially meeting" them and "addressing" them to alert educators to concepts that are taught or partially taught for deep understanding in a lesson compared to topics or ideas that we might touch upon but do not really teach for deep understanding. Educators may note that often several lessons are required to truly teach a concept. We understand the time constraints of the classroom may not allow for the time that is really required to truly teach a concept or benchmark; however, it is our goal to model effective instructional methods for science, math, and technology. As stated in Benchmarks for Science Literacy, "If we want students to learn science, mathematics, and technology well, we must radically reduce the sheer amount of material now being covered" (p XI)3.

[1] Project 2061, American Association for the Advancement of Science. (1993). Benchmarks for Science Literacy. New York. Oxford University Press. (p. VII).
[2] Project 2061. (p. XI).
[3] Project 2061. (p. XI).

Example of Lesson Objectives/Standards Table

Objectives:	Standards:
• Students will research and list the necessities for human survival in their Astro Journals. • They will write a story about human survival identifying these necessities, the consequences of not meeting them and how they are met. • After comparing characteristics of the Earth with other planets and moons, students will predict the features of Earth that they believe are crucial to human survival.	**Meets**: 2061: 6C 3-5 #1, 2 **Addresses**: 2061: 4B 6-8 #2

In addition to meeting benchmarks, the Astro-Venture Biology Educator Guide integrates some of the instructional methods that Project 2061 research has identified as being the most effective in teaching science, math, and technology. These include:

- Overall Purpose: We provide an overall purpose or goal and connect to this throughout. We base measurable objectives and assessments, which evaluate these objectives, on the overall purpose.
- Prerequisite Knowledge/Skills/Misconceptions: We identify prerequisite knowledge and common misconceptions. We alert educators to these misconceptions and provide questions or suggestions on how these might be addressed.
- Variety of Phenomena/Quality of Experiences: We provide a variety of highly interactive experiences and questioning strategies that require higher order thinking skills.
- Introducing Terms: We limit the use of terms and introduce them within context once the concept is understood.
- Welcoming All Students: We strive to make the content accessible to all student populations by providing suggestions for Accommodations for students who might benefit from modifications and Advanced Extensions for students who can benefit from additional challenges. In addition, we incorporate cooperative learning, hands-on activities and total physical response activities to facilitate the learning of students who speak English as a second language and to address multiple learning styles.

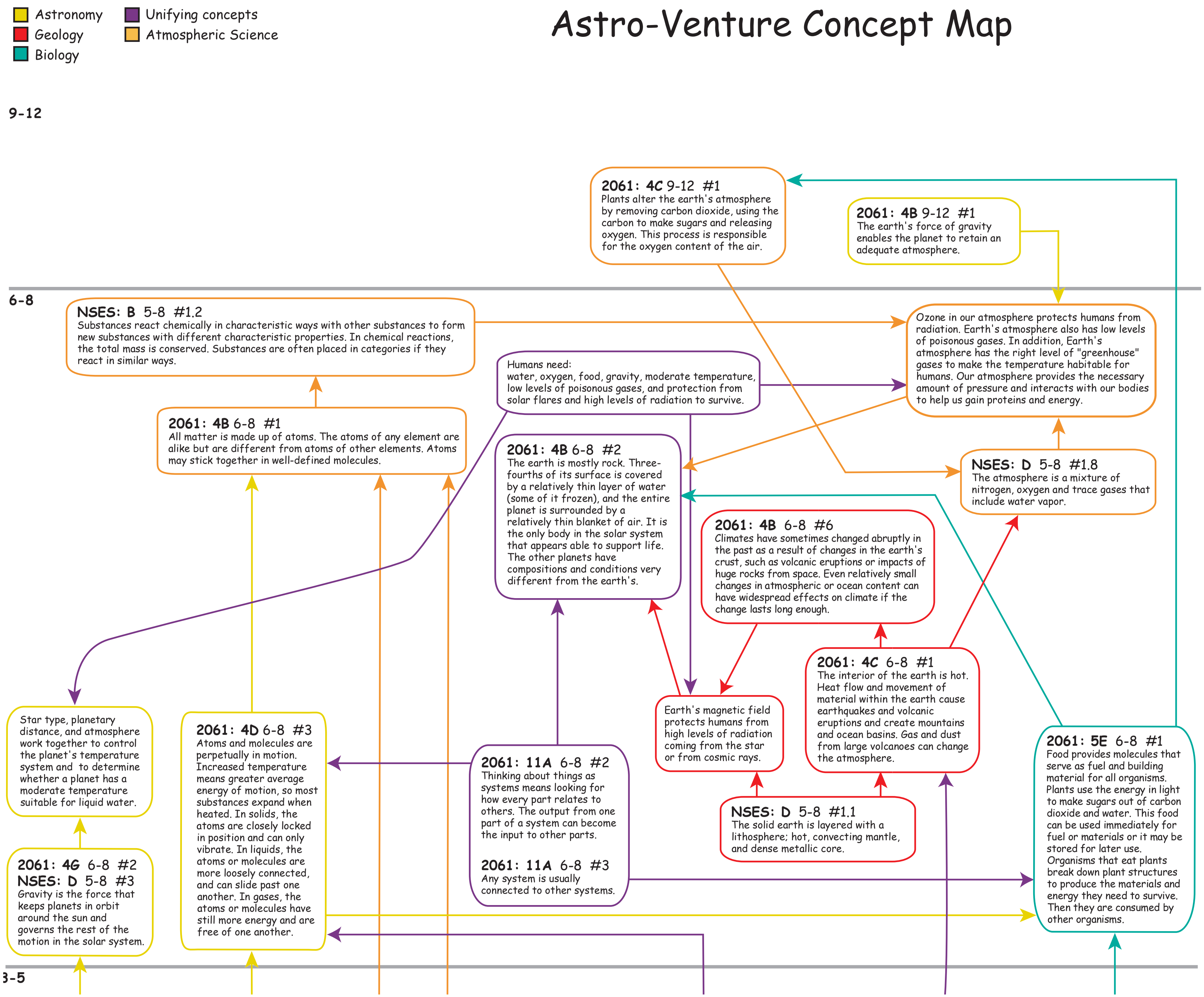
Astro-Venture Concept Map

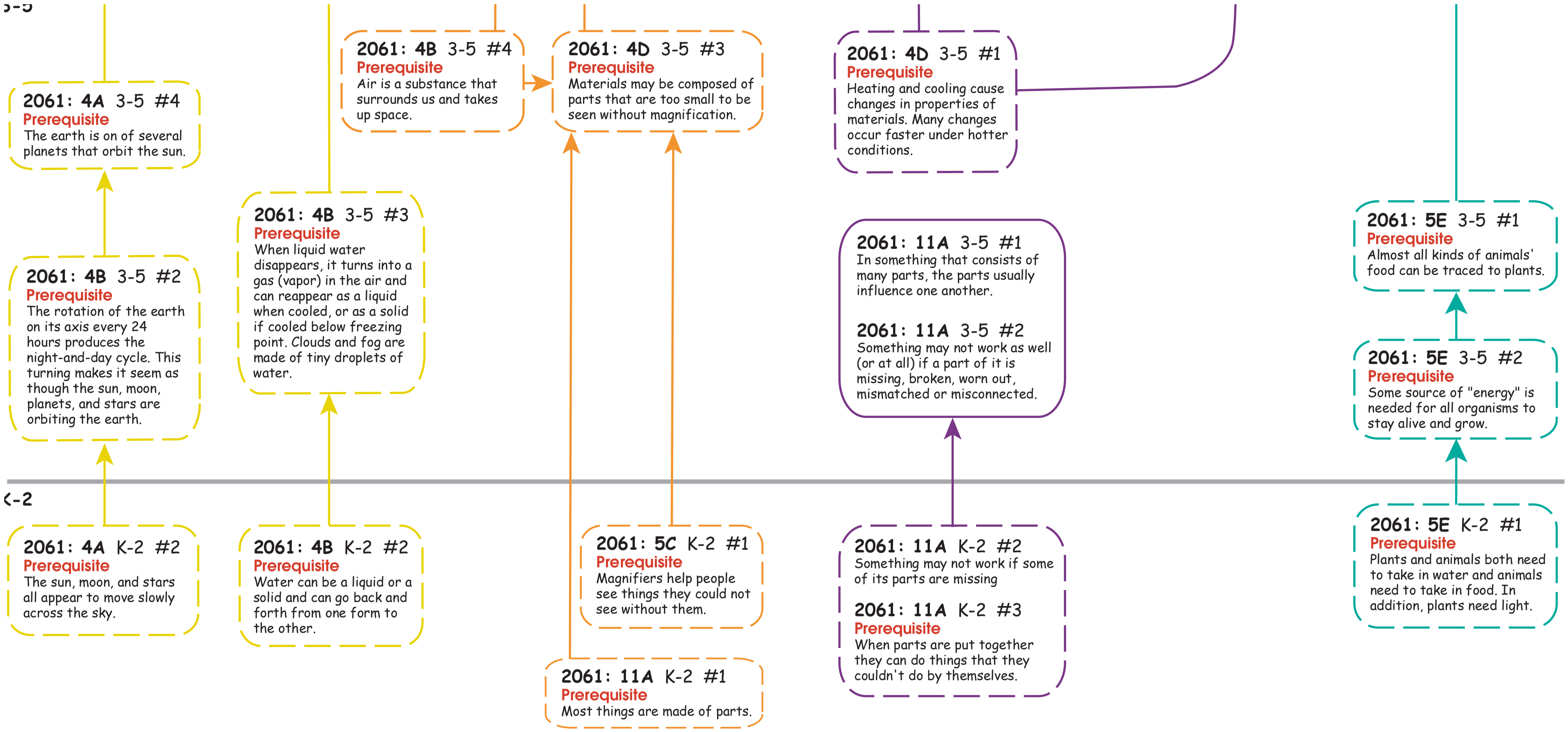
The map on the following two pages demonstrates the Benchmarks for Science Literacy and National Science Education Standards that have been identified for Astro-Venture. The map shows the overall concepts that are taught throughout Astro-Venture, as well as the benchmarks specific to the different sections. The map also shows the prerequisite benchmarks that students should have mastered prior to learning the benchmarks in Astro-Venture.

More information on the benchmarks and standards referenced can be found at the following Web addresses:

Standard/Benchmark Title	Web Address
American Association for the Advancement of Science: Project 2061	http://www.project2061.org/
National Science Education Standards (NSES)	http://www.nap.edu/readingroom/books/nses/html/
National Council of Teachers on Mathematics (NCTM)	http://standards.nctm.org/index.htm
International Society for Technology in Education (ISTE)	http://cnets.iste.org/
International Technology Education Association (ITEA)	http://www.iteawww.org/TAA/TAA.html

Astro-Venture Concept Map




3-5
K-2
2061: 4A 3-5 #4
Prerequisite
The earth is on of several planets that orbit the sun.
2061: 4B 3-5 #2
Prerequisite
The rotation of the earth on its axis every 24 hours produces the night-and-day cycle. This turning makes it seem as though the sun, moon, planets, and stars are orbiting the earth.
2061: 4A K-2 #2
Prerequisite
The sun, moon, and stars all appear to move slowly across the sky.
2061: 4B 3-5 #4
Prerequisite
Air is a substance that surrounds us and takes up space.
2061: 4B 3-5 #3
Prerequisite
When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below freezing point. Clouds and fog are made of tiny droplets of water.
2061: 4B K-2 #2
Prerequisite
Water can be a liquid or a solid and can go back and forth from one form to the other.
2061: 4D 3-5 #3
Prerequisite
Materials may be composed of parts that are too small to be seen without magnification.
2061: 5C K-2 #1
Prerequisite
Magnifiers help people see things they could not see without them.
2061: 11A K-2 #1
Prerequisite
Most things are made of parts.
2061: 4D 3-5 #1
Prerequisite
Heating and cooling cause changes in properties of materials. Many changes occur faster under hotter conditions.
2061: 11A 3-5 #1
In something that consists of many parts, the parts usually influence one another.
2061: 11A 3-5 #2
Something may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched or misconnected.
2061: 11A K-2 #2
Something may not work if some of its parts are missing
2061: 11A K-2 #3
Prerequisite
When parts are put together they can do things that they couldn't do by themselves.
2061: 5E 3-5 #1
Prerequisite
Almost all kinds of animals' food can be traced to plants.
2061: 5E 3-5 #2
Prerequisite
Some source of "energy" is needed for all organisms to stay alive and grow.
2061: 5E K-2 #1
Prerequisite
Plants and animals both need to take in water and animals need to take in food. In addition, plants need light.

Astro-Venture Biology Section

In the Biology section, students begin as Junior Biologists where they complete the online Biology Training module and discover the biological conditions that make Earth habitable to humans. When they have successfully completed their training, they earn their certificate and are promoted to Senior Biologist. They then engage in offline Biology lessons to discover why we need the biological conditions identified in Biology Training and are introduced to the flow of energy through food webs. The unit concludes with students connecting their new knowledge to systems they explored in the Astronomy, Atmospheric Science, and Biology units and summarizing their learning through a report of their findings to the World Science Foundation that includes recommendations on maintaining the balance of vital Earth systems.

Astro-Venture Biology Lessons, Objectives and Standards Alignment

Unit Concept: Human survival is dependent upon the flow of energy through food webs.

Overview of the Biology unit: Using an online, multimedia module, students change the amounts of energy, producers, consumers, and decomposers and draw conclusions about which factors are necessary for human survival. Students then engage in classroom activities that explore the importance of food for energy and building materials and how living things get their energy and building materials. They further explore the cycle of matter and compare and contrast this with the flow of energy. Finally, they connect their learning to the systems they explored in Astronomy, Atmospheric Sciences and Geology.

The objectives and standards of Astro-Venture Biology are broken down into seven lessons, as shown in the table on the following two pages.

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
1. Biology Training Module	Certain biologic conditions help to support human survival.	What biologic conditions are required for human survival?	• Students make changes to Earth's ecosystem and write descriptive, objective observations of the effects of these changes on Earth. • Students will identify the characteristics of Earth's ecosystem that are required to allow for human survival.	**Meets:** NSES: A 5-8 #1 ISTE: 3, 5 **Partially meets:** 2061: 5A (6-8) #5 NSES: C (5-8) #4.2, #4.3 **Addresses:** 2061: 4B 6-8 #2
2. The Importance of Food	Food provides molecules that serve as fuel and building material for all organisms.	Why do living things need food? How is food used by living things?	• Students will record observations of what happens to food when they eat it. • Students will describe the important roles that sugars, vitamins, minerals, water, and blood play in their bodies. • Students will illustrate and describe the process that our bodies use to break down food, the parts that make up the food, and why each is important.	**Partially Meets:** 2061: 5E (6-8) #1

3. Producers Make Their Own Food	Plants use the energy in light to make sugars out of carbon dioxide and water. Oxygen is released in this process.	How do producers make food?	• Students will use the inquiry process to design and carry out an experiment to determine what plants need to make food. • Students will describe what is needed to care for a rare plant. • Students will explain why producers are important to other living things.	**Partially Meets:** 2061: 5E (6-8) #1 NSES: *C* (5-8) 4.2 NSES: *C* (5-8) 4.3 **Addresses:** 2061: 5E (6-8) #3 NSES: D (5-8) 1.11 NCTM: 4, 5, 9
4. Consumers Get Energy from Other Living Things	All animals, including humans, are consumers that obtain food by eating other organisms. When organisms eat plants, their bodies break down the plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms.	How do animals get their energy?	• Students will categorize living things based on subjective categories they feel are important. • Students will make and analyze observations of their own energy levels and possible factors that cause changes in these levels. • Students will diagram and explain an energy flow that includes humans and will describe the role of photosynthesis and aerobic respiration in this flow. • Students will explain why other living things are important to human survival.	**Partially Meets:** 2061: 5E (6-8) #1 NSES: *C* (5-8) 4.2 **Addresses:** NSES: *C* (5-8) 4.3
5. Decomposers Get Energy from Dead Things	Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food.	What happens to dead plants and animals?	• Students will use the inquiry process to design and carry out an experiment to determine the factor or factors that cause rotting. • Students will complete their diagrams of the energy flow by adding decomposers and will explain how decomposers get their energy. • Students will explain why decomposers are important to other living things.	**Partially Meets:** NSES: *C* (5-8) 4.2 **Addresses:** 2061: 5E (6-8) #1 2061: 5D (6-8) #2 NCTM: 5, 9

6. The Cycle of Matter	Over a long time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment. As in all material systems, the total amount of matter remains constant, even though its form and location change.	In food webs, is matter ever created or destroyed?	• Students will draw and explain the cycle of matter, how matter is transferred in this cycle, changing location and form while maintaining the same number of atoms. • Students will draw and explain the flow of energy and will compare and contrast a cycle and a flow.	**Meets:** 2061: 5E (6-8) #2
7. Biology Conclusion: Summarizing Learning	The biological energy flow identifies the relationships among producers, consumers, and decomposers in an ecosystem that are important for human survival.	How is the flow of energy important for human survival?	• Students will draw and explain concept maps that show how the members of the food web interact with many different systems to support human habitability. • Students will write a report of their findings explaining how all astronomical, atmospheric, geological, and biological features work together as a system to support human habitability and how this balance can be maintained.	**Partially meets:** NSES: C 5-8 #4.2 NSES: C 5-8 #4.3 **Addresses:** 2061 4B 6-8 #2 2061 11A 3-5 #1 2061 11A 3-5 #2 2061 11A 6-8 #2 2061 11A 6-8 #3 NSES C 5-8 #1.5

Guide to the Parts of the Lessons

Lesson Introduction and Preparation

Each lesson begins with an Overview, the Main Concept of the lesson, and the Scientific Question associated with the concept. The lesson breaks down the Objectives as they are aligned with the National Education Standards and describes how these objectives will be evaluated in the Assessment. It further gives an Abstract of the lesson, breaks down the Major Concepts of the lesson, and lists Prerequisite Concepts that students are expected to have mastered before engaging in the lesson. All of this gives the educator a good overview of what will be covered, and of how it will be taught and assessed.

The first part of each lesson also gives an outline of a Suggested Timeline that is based on 45-minute class periods. Time will vary depending on the educator's pacing, the student levels, and dynamics of the class; however, the timeline provides some basic guidelines for the educator. Materials and Equipment and the Preparation of these materials and equipment are also described and listed so that teachers can easily see what they will need to prepare for the lesson ahead of time. Finally, a table provides suggestions on Accommodations for students that may need more support as well as Advanced Extensions for students who may need further challenging.

The Five "E's"

The Astro-Venture Biology Educator Guide intends to model the scientific inquiry process by using the five "E's." These stand for Engage, Explore, Explain, Extend/Apply, and Evaluate. The important factor that distinguishes this lesson format from lessons of other content areas is that students are not told a concept, but are led to explore and discover the concept so that once they reach the Explain section they have an experience on which to base the concept. They are then asked to apply this new concept to other situations and are evaluated on their ability to do so.

Throughout the lessons, a Question and Answer dialogue is modeled. Of course, no class will follow this script; however, the dialogue models the kinds of discussions educators should facilitate in an effort to help guide students toward developing their own understanding of the concepts and drawing conclusions. The dialogue also models questions that stimulate higher order thinking skills rather than rote memorization of facts.

In addition, the lessons also include periodic Notes to Teacher and cues to Misconceptions. The Notes provide additional background information or suggestions that may be helpful to the educator. The educator may determine that some of the information is appropriate to share with their students, while other information is not. It is hoped that by alerting educators to Misconceptions, educators will try to bring out these misconceptions with their students and help their students to address the misconceptions. Misconceptions are one of the most challenging areas for science educators, because research shows that we must disprove our own misconceptions before we can accept new concepts. We cannot be told these concepts, but must discover them ourselves.

Engage

The Engage section of each lesson provides guidelines for drawing on students' prior knowledge, building on previous lesson concepts, introducing the purpose of the lesson and the Scientific Question that will be explored.

Explore

In the Explore section, students sometimes are asked to make Predictions or Hypotheses in response to the Scientific Question and are given an activity that will help them to collect data and evidence to answer the Scientific Question.

Explain

In the Explain section, students reflect on the Explore activity by recording their Results and Conclusions. They discuss these as a class or in small groups and receive feedback on their ideas. They may also engage in readings or additional demonstrations that provide further explanation of the concepts they have explored.

Extend/Apply

In the Extend/Apply section, students are given an activity or assignment in which they demonstrate their understanding of the concept and/or apply it to another situation. Again they receive feedback on their learning.

Evaluate

In the Evaluate section, students are evaluated on their understanding of the concept. In some cases, rubrics are provided for evaluation of this learning. In addition, students discuss and summarize the main concepts of the lesson, which is posted on the wall so students can see how the concepts build on each other.

Lesson Blacklines

The end of each lesson includes the blacklines needed for class set duplication or for creating transparencies for that particular lesson. These can be printed out and duplicated, as needed. Astro Journals are included for most lessons and model the scientific inquiry process used throughout each lesson.

Rubrics

Some assignments in Astro-Venture have a rubric for evaluation. Generally, these rubrics are included directly on the assignment sheets so that students know what they are expected to do. Before the students begin the assignment, the teacher should go over the rubric so that everyone understands the expectations.

When using the rubrics to evaluate student work, there are a few things to keep in mind that will make the process easier and more effective.

1. The teacher should spend some time thinking about the assignment and the rubric before reviewing it with the students. The teacher's thoughts may change after discussing it with the students, but everyone will benefit from the teacher knowing what she is expecting.

2. The four levels of the rubric describe general levels of proficiency. Few assignments will ever be exactly a "3" or exactly a "2." Certain expectations will be met more proficiently than others. To assign a score, the teacher should identify the score that "best fits" the work. If there is a great discrepancy, then the teacher can consider multiple scores, although this will create more work and difficulties in reporting.

3. Written assignments, such as essays, focus on content and reasoning. The teacher may also use district standards for evaluating the writing process.

4. Visual assignments, such as illustrations, do include expectations for the appearance of the illustration. The focus of these expectations is the clarity of the information being presented in the illustration. Despite the great advancements in digital imaging technology, botanists, entomologists, and archeologists (among others) still rely on specially trained artists to record new findings. The ability to express visual information clearly and accurately is a skill worth developing. Appearance cannot substitute for the accuracy of the information, but it can enhance the expression of this information. That enhancement is worth acknowledging.

Scientific Inquiry Evaluation Rubric For Evaluating Astro Journal Entries

There are many ways of approaching rubrics for assessment, each with its own strengths and weaknesses. Whatever the approach, the goal is the same--providing feedback for students so that they can meet or exceed the standards or other expectations upon which they are focusing.

With this goal in mind, it is essential that students have many opportunities to work with the rubric: clarifying and analyzing the expectations, going over assessed work to understand the scores, evaluating their own work and their peers' work, and coming up with evidence to explain and justify those scores. Rubrics are only useful as long as they help students to understand how to improve their work and aid in their learning process.

The following rubric for inquiry in the Astro Journal divides the Astro Journal steps into four components and states expectations for each of those components. Scoring is done for each component in reference to the degree to which the expectations are met.

Component	Expectations
Hypothesis/ Prediction	• Clearly stated • Specific enough to be testable/observable and give a meaningful result • Has basis in solid information or observations and a logical reasoning process
Materials, Procedures, and Data	• Clearly stated • Complete • Accurate and tied directly to hypothesis and scientific question
Results	• Clearly stated • Refers directly to Scientific Question and data • Draws a reasonable conclusion from that data
Conclusions	• Clearly stated • States how hypothesis/prediction was confirmed and/or altered • Refers directly to findings, observations, and/or data to explain why thoughts were changed.

Scores:	
4:	Expectations Exceeded
3:	Expectations Met
2:	Expectations Not Quite Met
1:	Expectations Not Met

The score of "3" indicates that the expectations were met. The score of "4" indicates that the expectations were exceeded. The difference between those two scores is somewhat subjective and should be worked on by each teacher (or group of teachers trying to use the rubric in a standard fashion). The score of "2" indicates that expectations were not quite met while the score of "1" indicates that the expectations were not met. The difference between those two scores is again somewhat subjective, but some thought into the implications of these scores might be helpful in distinguishing between the two. A "2" indicates that the student needs some assistance and work in meeting the expectations. A "1" indicates the student needs much assistance and work in meeting the expectations.

For this reason, just providing the students with a score, especially students with scores of "2" or "1" is not enough feedback. The student needs to know the reasons why a particular score was given. (Note: even students with scores of "3" and "4" benefit from learning why their work received the scores that it did. Many of these students are not conscious of what they did to receive those scores and might not repeat what they did, if it is not made explicit to them.)

Consider the following example. In Atmosphere Lesson 5: Properties of Matter, the students have to develop a hypothesis about what causes matter to change state. Here are three sample (fictional) responses.

(A) Heat causes matter to change its state. I've watched ice cubes melt outside of the freezer and I've watched water turn to steam when you heat it up.

(B) Temperature causes matter to change its state.

(C) Particles go into stuff and energize it because matter is just energy.

Response "A" is clearly stated and specific enough to be tested leading to a meaningful result. It also has an explanation that is based on solid observation and reasoning. The fictional student is saying that she has made two observations that show a consistent pattern that explains the phenomena--a logical reasoning process. Notice that the hypothesis is not quite correct. Regardless of that fact, the hypothesis should score at least a "3" and possibly a "4" depending on how the teacher and students understand the rubric.

Response "B" is not grounded in any information or observations and shows no evidence of a reasoning process. In certain ways, it is not even clear. In short, this hypothesis should score only a "2," and the student should be told to base his hypothesis in more solid information or observations and to indicate how the hypothesis was reasoned from those sources.

Response "C" is not very clear. The student may or may not have based this hypothesis on solid information, observations, and reasoning. You, as the teacher, just do not know. The hypothesis should score only a "2" or possibly even a "1." In the long run, the actual score of the hypothesis is less important than the student learning what is needed in order to meet the expectations and put together a good hypothesis.

In conclusion, using this rubric will require an investment of time and energy by teacher and students in creating an understanding of what these expectations mean and how they will be demonstrated in student work. If that process leads to changes in the rubric, so much the better. All the participants in that process will have a richer understanding of the process and will be better poised to engage in authentic inquiry experiences.

Educational Standards List

Benchmarks for Science Literacy (2061)

1 **The Nature of Science**
- A. The Scientific World View
- B. Scientific Inquiry
- C. Scientific Enterprise

2 **The Nature of Mathematics**
- A. Patterns and Relationships
- B. Mathematics, Science and Technology
- C. Mathematical Inquiry

3 **The Nature of Technology**
- A. Technology and Science
- B. Design and Systems
- C. Issues in Technology

4 **The Physical Setting**
- A. The Universe
- B. The Earth

6-8

#2. The earth is mostly rock. Three-fourths of its surface is covered by a relatively thin layer of water (some of it frozen), and the entire planet is surrounded by a relatively thin blanket of air. It is the only body in the solar system that appears able to support life. The other planets have compositions and conditions very different from the earth's.

- C. Processes That Shape the Earth
- D. Structure of Matter
- E. Energy Transformations
- F. Motion
- G. Forces of Nature

5 **The Living Environment**
- A. Diversity of Life

6-8

#5 All organisms, including human species, are part of and depend on two main interconnected global food webs. One includes microscopic ocean plants, the animals that feed on them, and finally the animals that feed on those animals. The other web includes land plants, the animals that feed on them, and so forth. The cycles continue indefinitely, because organisms decompose after death to return food material to the environment.

- B. Heredity
- C. Cells
- D. Interdependence of Life

6-8

#2 Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.

E. Flow of Matter and Energy

6-8

#1 Food provides molecules that serve as fuel and building material for all organisms. Plants use the energy in light to make sugars out of carbon dioxide and water. This food can be used immediately for fuel or materials or it may be stored for later use. Organisms that eat plants break down the plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms.

#2 Over a long time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment. As in all material systems, the total amount of matter remains constant, even though its form and location change.

#3 Energy can change from one form to another in living things. Animals get energy from oxidizing their food, releasing some of its energy as heat. Almost all food energy comes originally from sunlight.

F. Evolution of Life

6 The Human Organism

A. Human Identity
B. Human Development
C. Basic Functions
D. Learning
E. Physical Health
F. Mental Health

7 Human Society

A. Cultural Effects on Behavior
B. Group Behavior
C. Social Change
D. Social Trade-Offs
E. Political and Economic Systems
F. Social Conflict
G. Global Interdependence

8 The Designed World

A. Agriculture
B. Materials and Manufacturing
C. Energy Sources and Use
D. Communication
E. Information Processing
F. Health Technology

9 The Mathematical World

A. Numbers
B. Symbolic Relationships
C. Shapes
D. Uncertainty
E. Reasoning

10 Historical Perspectives

A. Displacing the Earth from the Center of the Universe
B. Uniting the Heavens and Earth
C. Relating Matter & Energy and Time & Space
D. Extending Time
E. Moving the Continents
F. Understanding Fire
G. Splitting the Atom
H. Explaining the Diversity of Life
I. Discovering Germs
J. Harnessing Power

11 Common Themes

A. Systems

3-5

#1 In something that consists of many parts, the parts usually influence on another.

#2 Something may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched or misconnected.

6-8

#2 Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.

#3 Any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.

B. Models
C. Constancy and Change
D. Scale

12 Habits of the Mind

A. Values and Attitudes
B. Computation and Estimation
C. Manipulation and Observation
D. Communication Skills
E. Critical-Response Skills

National Science and Education Standards (NSES)

Unifying Concepts and Processes (UCP)

K-12

1. Systems, order and organization
2. Evidence, models and explanation
3. Change, constancy, and measurement
4. Evolution and equilibrium
5. Form and function

Content Standard A: Science as Inquiry

K-12

A1. Abilities necessary to do scientific inquiry
A2. Understanding about scientific inquiry

Content Standard B: Physical Science

K-4

1. Properties of objects and materials
2. Position and motion of objects
3. Light, heat, electricity and magnetism

5-8

1. Properties and changes of properties in matter
2. Motions and forces
3. Transfer of energy

9-12

1. Structure of atoms
2. Structure and properties of matter
3. Chemical reactions
4. Motions and forces
5. Conservation of energy and increase in disorder
6. Interactions of energy and matter

Content Standard C: Life Science

K-4

1. Characteristics of organisms
2. Life cycle of organisms
3. Organisms and environments

5-8

1. Structure and function in living systems
   - #1.5 The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and for protection from disease. These systems interact with one another.
2. Reproduction and heredity
3. Regulation and behavior
4. Populations and ecosystems
   - #4.2 Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms are producers--they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.
   - #4.3 For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.
5. Diversity and adaptations of organisms

9-12

1. The cell
2. Molecular basis of heredity
3. Biological evolution
4. Interdependence of organisms
5. Matter, energy and organization in living systems
6. Behavior of organisms

Content Standard D: Earth and Space Science

K-4

1. Properties of earth materials
2. Objects in the sky
3. Changes in earth and sky

5-8

1. Structure of the earth system
   - #1.11 Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.
2. Earth's history
3. Earth in the solar system

9-12

1. Energy in the earth systems
2. Geochemical cycles
3. Origin and evolution of the earth system
4. Origin and evolution of the universe

Content Standard E: Science and Technology

K-4

1. Abilities to distinguish between natural objects and objects made by humans
2. Abilities of technological design
3. Understanding about science and technology

5-12

1. Abilities of technological design
2. Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

K-4

1. Personal Health
2. Characteristics and changes in population
3. Types of resources
4. Changes in environments
5. Science and technology in local challenges

5-8

1. Personal health
2. Populations, resources and environments
3. Natural hazards
4. Risks and benefits
5. Science and technology in society

9-12

1. Personal and community health
2. Population growth
3. Natural resources
4. Environmental quality
5. Natural and human-induced hazards
6. Science and technology in local, national and global challenges

Content Standard G: History and Nature of Science

K-4

1. Science as a human endeavor

5-8

1. Science as a human endeavor
2. Nature of science

9-12

1. Science as a human endeavor
2. Nature of scientific knowledge
3. Historical perspectives

National Council of Teachers of Mathematics (NCTM) Standards

STANDARD 1: NUMBER AND OPERATION

Mathematics instructional programs should foster the development of number and operation sense so that all students—

- understand numbers, ways of representing numbers, relationships among numbers, and number systems;
- understand the meaning of operations and how they relate to each other;
- use computational tools and strategies fluently and estimate appropriately.

STANDARD 2: PATTERNS, FUNCTIONS, AND ALGEBRA

Mathematics instructional programs should include attention to patterns, functions, symbols, and models so that all students—

- understand various types of patterns and functional relationships;
- use symbolic forms to represent and analyze mathematical situations and structures;
- use mathematical models and analyze change in both real and abstract contexts.

STANDARD 3: GEOMETRY AND SPATIAL SENSE

Mathematics instructional programs should include attention to geometry and spatial sense so that all students—

- analyze characteristics and properties of two- and three-dimensional geometric objects;
- select and use different representational systems, including coordinate geometry and graph theory;
- recognize the usefulness of transformations and symmetry in analyzing mathematical situations;
- use visualization and spatial reasoning to solve problems both within and outside of mathematics.

STANDARD 4: MEASUREMENT

Mathematics instructional programs should include attention to measurement so that all students—

- understand attributes, units, and systems of measurement;
- apply a variety of techniques, tools, and formulas for determining measurements.

STANDARD 5: DATA ANALYSIS, STATISTICS, AND PROBABILITY

Mathematics instructional programs should include attention to data analysis, statistics, and probability so that all students—

- pose questions and collect, organize, and represent data to answer those questions;
- interpret data using methods of exploratory data analysis;
- develop and evaluate inferences, predictions, and arguments that are based on data;
- understand and apply basic notions of chance and probability.

STANDARD 6: PROBLEM SOLVING

Mathematics instructional programs should focus on solving problems as part of understanding mathematics so that all students—

- build new mathematical knowledge through their work with problems;
- develop a disposition to formulate, represent, abstract, and generalize in situations within and outside mathematics;
- apply a wide variety of strategies to solve problems and adapt the strategies to new situations;
- monitor and reflect on their mathematical thinking in solving problems.

STANDARD 7: REASONING AND PROOF

Mathematics instructional programs should focus on learning to reason and construct proofs as part of understanding mathematics so that all students—

- recognize reasoning and proof as essential and powerful parts of mathematics;
- make and investigate mathematical conjectures;
- develop and evaluate mathematical arguments and proofs;
- select and use various types of reasoning and methods of proof as appropriate.

STANDARD 8: COMMUNICATION

Mathematics instructional programs should use communication to foster understanding of mathematics so that all students—

- organize and consolidate their mathematical thinking to communicate with others;
- express mathematical ideas coherently and clearly to peers, teachers, and others;
- extend their mathematical knowledge by considering the thinking and strategies of others;
- use the language of mathematics as a precise means of mathematical expression.

STANDARD 9: CONNECTIONS

Mathematics instructional programs should emphasize connections to foster understanding. Of mathematics so that all students—

- recognize and use connections among different mathematical ideas;
- understand how mathematical ideas build on one another to produce a coherent whole;
- recognize, use, and learn about mathematics in contexts outside of mathematics.

STANDARD 10: REPRESENTATION

Mathematics instructional programs should emphasize mathematical representations to foster understanding of mathematics so that all students—

- create and use representations to organize, record, and communicate mathematical ideas;
- develop a repertoire of mathematical representations that can be used purposefully, flexibly, and appropriately;
- use representations to model and interpret physical, social, and mathematical phenomena.

International Society for Technology in Education (ISTE) Standards

TECHNOLOGY FOUNDATION STANDARDS FOR STUDENTS

1. Basic operations and concepts
   - Students demonstrate a sound understanding of the nature and operation of technology system.
   - Students are proficient in the use of technology.

2. Social, ethical, and human issues
   - Students understand the ethical, cultural and societal issues related to technology.
   - Students practice responsible use of technology systems, information and software.
   - Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits and productivity.

3. Technology productivity tools
   - Students use technology tools to enhance learning, increase productivity and promote creativity.
   - Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications and produce other creative works.

4. Technology communications tools
   - Students use telecommunications to collaborate, publish and interact with peers, experts and other audiences.
   - Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.

5. Technology research tools
   - Students use technology to locate, evaluate and collect information from a variety of sources.
   - Students use technology tools to process data and report results.
   - Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

6. Technology problem-solving and decision making tools
   - Students use technology resources for solving problems and making informed decisions.
   - Students employ technology in the development of strategies for solving problems in the real world.